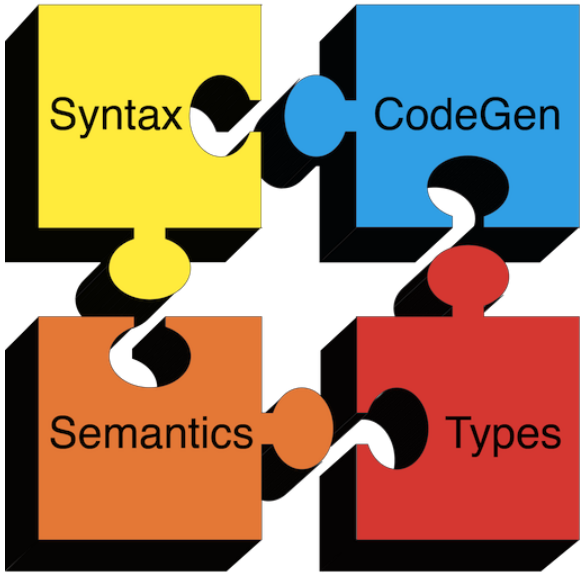

Compilers

Handles

Handles

Bottom-up parsing uses two actions:

Shift

$$ABC|xyz \Rightarrow ABCx|yz$$

Reduce

$$Cbxy|ijk \Rightarrow CbA|ijk$$

Handles

- Left string can be implemented by a stack
  - Top of the stack is the |
- Shift pushes a terminal on the stack
- Reduce
  - pops 0 or more symbols off of the stack
    - production rhs
  - pushes a non-terminal on the stack
    - production lhs

Handles

- How do we decide when to shift or reduce?

- Example grammar:

  $E \rightarrow T + E \mid T$

  $T \rightarrow \text{int} * T \mid \text{int} \mid (E)$

- Consider step int | * int + int
  - We could reduce by $T \rightarrow \text{int}$ giving T | * int + int
  - A fatal mistake!
    - No way to reduce to the start symbol E

Handles

- Intuition: Want to reduce only if the result can still be reduced to the start symbol

- Assume a rightmost derivation

$$S \rightarrow^* \alpha X \omega \rightarrow \alpha\beta\omega$$

- Then $\alpha\beta$ is a *handle* of $\alpha\beta\omega$

Handles

- Handles formalize the intuition
  - A handle is a reduction that also allows further reductions back to the start symbol
- We only want to reduce at handles
- Note: We have said what a handle is, not how to find handles

Handles

$E \rightarrow E' \mid E' + E$

$E' \rightarrow -E' \mid id \mid (E)$

Given the grammar at right, identify the handle for the following shift-reduce parse state: $E' + -id \mid + -(id + id)$

- $E' + -id$
- id
- $-id$
- $E' + -E'$

Handles

Important Fact #2 about bottom-up parsing:

In shift-reduce parsing, handles appear only at the top of the stack, never inside

Handles

- Informal induction on # of reduce moves:
- True initially, stack is empty
- Immediately after reducing a handle
  - right-most non-terminal on top of the stack
  - next handle must be to right of right-most non-terminal, because this is a right-most derivation
  - Sequence of shift moves reaches next handle

Handles

- In shift-reduce parsing, handles always appear at the top of the stack
- Handles are never to the left of the rightmost non-terminal
  - Therefore, shift-reduce moves are sufficient; the | need never move left
- Bottom-up parsing algorithms are based on recognizing handles